CLAIMS

1. A monolithic semiconductor-piezoelectric structure comprising:

a substrate of a first monocrystalline semiconductor material;

at least one strain-relief material layer, each said at least one strain-relief material layer overlying a respective portion of said monocrystalline semiconductor substrate;

at least one portion of a piezoelectric material, each said portion overlying a respective one of said at least one strain-relief material layer; and

an electro-acoustic device at least partially in at least one said portion of piezoelectric material.

2. The semiconductor-piezoelectric structure of claim 1 wherein said semiconductor material is silicon.

3. The semiconductor-piezoelectric structure of claim 1 wherein said piezoelectric material is a metallic oxide.

4. The semiconductor-piezoelectric structure of claim 1 wherein said piezoelectric material is lithium niobate.

5. The semiconductor-piezoelectric structure of claim 1 wherein said piezoelectric material is lithium tantalate.

6. The semiconductor-piezoelectric structure of claim 1 wherein said strain-relief material is $Sr_zBa_{1-z}TiO_3$, where z has a value chosen between 0 and 1.

7. The semiconductor-piezoelectric structure of claim 1 wherein said strain-relief material comprises an amorphous material.

8. The semiconductor-piezoelectric structure of claim 1 wherein said strain-relief material comprises a crystalline material.

9. The semiconductor-piezoelectric structure of claim 1 wherein said strain-relief material comprises an oxide of silicon.

10. The semiconductor-piezoelectric structure of claim 1 wherein said electro-acoustic device is a passive surface acoustic wave device.

11. The semiconductor-piezoelectric structure of claim 1 wherein said electro-acoustic device is an active device.

12. The semiconductor-piezoelectric structure of claim 11 wherein said active device comprises an acoustic charge transport device.

13. The device of claim 12 wherein a substantial portion of charge transfer through said acoustic charge transport device is through a semiconductor substrate region proximate to said piezoelectric layer.

14. The device of claim 12 wherein traveling potential wells transport charge in said device, and wherein said potential wells are piezoelectrically coupled to an acoustic wave transduced in said piezoelectric layer.

15. The monolithic semiconductor-piezoelectric structure of claim 1, further comprising:

at least one semiconductor device formed in a semiconductor portion of said substrate; and

at least one electrical connection between one of said semiconductor devices and said electro-acoustic device.

16. A method for integrating an electro-acoustic device with a semiconductor device in a circuit, said method comprising:

providing a monolithic structure that comprises:

a substrate of a first monocrystalline semiconductor material;

at least one strain-relief material layer, each said at least one strain-relief material layer overlying a respective portion of said monocrystalline semiconductor substrate;

at least one portion of a piezoelectric material, each said portion overlying a respective one of said at least one strain-relief material layer,

forming an electro-acoustic device at least partially in at least one said portion of piezoelectric material;

forming a semiconductor device at least partially in a semiconductor region in said substrate; and

providing an electrical connection between said semiconductor device and said electro-acoustic device.

17. The method of claim 16 wherein said first monocrystalline semiconductor material is semiconductor silicon.

18. The method of claim 16 wherein said piezoelectric material comprises a metallic oxide.

19. The method of claim 16 wherein said piezoelectric material is lithium niobate.

20. The method of claim 16 wherein said piezoelectric material is lithium tantalate.

21. The method of claim 16 wherein said strain-relief material comprises $Sr_zBa_{1-z}TiO_3$, where z has a value chosen between 0 and 1.

22. The method of claim 16 wherein said strain-relief material comprises a crystalline material.

23. The method of claim 16 wherein said strain-relief material comprises an amorphous material formed by amorphizing a crystalline material by heat treatment during fabrication of said monolithic structure.

24. The method of claim 16 wherein said strain-relief material comprises an oxide of silicon.

25. The method of claim 16 wherein said electro-acoustic device comprises a passive surface acoustic wave device.

26. The method of claim 16 wherein said electro-acoustic device comprises an active device.

27. The method of claim 26 wherein said active device comprises an acoustic charge transport device.

28. The method of claim 27 wherein a substantial portion of charge transfer in said acoustic charge transport device is through a semiconductor substrate region proximate to said piezoelectric layer.

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29. The device of claim 26 wherein said charge transport is by way of traveling potential wells, and wherein said potential wells are piezoelectrically coupled to an acoustic wave transduced in said piezoelectric layer.

30. A method for forming a semiconductor-piezoelectric monolithic structure having an electro-acoustic device, comprising:

preparing a surface on a first monocrystalline semiconductor material substrate for epitaxial growth;

preparing a strain-relief layer on at least a portion of said surface; and

epitaxially forming a piezoelectric material layer on said strain-relief layer.

31. The method of claim 30 wherein said first monocrystalline semiconductor material comprises semiconductor silicon.

32. The method of claim 30 wherein said piezoelectric material comprises a metallic oxide.

33. The method of claim 30 wherein said piezoelectric material is lithium niobate.

34. The method of claim 30 wherein said piezoelectric material is lithium tantalate.

35. The method of claim 30 wherein said strain-relief layer comprises $Sr_zBa_{1-z}TiO_3$, where z has a value chosen between 0 and 1.

36. The method of claim 30 wherein said strain-relief material comprises a crystalline material.

37. The method of claim 30 wherein said strain-relief material comprises an amorphous material.

38. The method of claim 37 wherein said amorphous material is formed by interfacial oxidation of said substrate during said epitaxially forming a piezoelectric material layer.

39. The method of claim 30 wherein said preparing a strain-relief layer and said epitaxially forming a piezoelectric material layer comprise:

forming an initial crystalline strain-relief layer;

forming a thin piezoelectric epitaxial layer on said initial strain-relief layer; and

amorphizing said initial crystalline strain-relief layer.

40. The method of claim 30 further comprising forming said electro-acoustic device at least partially in said piezoelectric material layer.

41. The method of claim 30 wherein said forming said electro-acoustic device comprises forming a passive surface acoustic wave device.

42. The method of claim 30 wherein said forming said electro-acoustic device comprises forming an active device.

43. The method of claim 42 wherein said forming an active device comprises forming an acoustic charge transport device.

44. The method of claim 43 wherein said forming an acoustic charge transport device comprises forming a device wherein a substantial portion of charge transfer is through a semiconductor substrate region proximate to said piezoelectric material layer.

45. The method of claim 43 wherein said forming a device comprises forming said device wherein said charge transport is by way of traveling potential wells, and wherein said potential wells are piezoelectrically-coupled to an acoustic wave transduced in said piezoelectric layer.

46. A monolithic semiconductor-piezoelectric structure comprising:

a substrate of a first monocrystalline semiconductor material;

at least one accommodating layer, each said at least one accommodating layer overlying a respective portion of said monocrystalline semiconductor substrate wherein said accommodating layer is formed of piezoelectric material;

an electro-acoustic device at least partially in at least one said one accommodating layer; and

at least a second monocrystalline semiconductor material, each said at least a second monocrystalline semiconductor material overlying a respective one of said at least one accommodating layer.

47. The semiconductor-piezoelectric structure of claim 46 wherein said first monocrystalline semiconductor comprises a Group IV semiconductor.

48. The semiconductor-piezoelectric structure of claim 46 wherein said piezoelectric material comprises a metallic oxide.

49. The semiconductor-piezoelectric structure of claim 48 wherein said metallic oxide comprises $Sr_zBa_{1-z}TiO_3$, where z has a value chosen between 0 and 1.

50. The semiconductor-piezoelectric structure of claim 46 wherein said piezoelectric material comprises lithium niobate.

51. The semiconductor-piezoelectric structure of claim 46 wherein said piezoelectric material comprises lithium tantalate.

52. The semiconductor-piezoelectric structure of claim 46 wherein said electro-acoustic device comprises a passive surface acoustic wave device.

53. The semiconductor-piezoelectric structure of claim 46 wherein said electro-acoustic device comprises an active device.

54. The semiconductor-piezoelectric structure of claim 53 wherein said active device comprises an acoustic charge transport device.

55. The device of claim 53 wherein a substantial portion of charge transfer through said acoustic charge transport device is through a semiconductor substrate region proximate to said piezoelectric layer.

56. The device of claim 53 wherein traveling potential wells transport charge in said device, and wherein said potential wells are piezoelectrically coupled to an acoustic wave transduced in said piezoelectric layer.

57. The monolithic semiconductor-piezoelectric structure of claim 46 wherein said second semiconductor comprises a semiconductor selected from the group of Group IV, Group III-V, and Group II-VI-semiconductors.

58. The monolithic semiconductor-piezoelectric structure of claim 46, further comprising:

at least one semiconductor device, and

at least one electrical connection between one of said semiconductor devices and said electro-acoustic device.

59. The monolithic semiconductor-piezoelectric structure of claim 58, wherein said at least one semiconductor device is formed at least partially in said substrate.

60. The monolithic semiconductor-piezoelectric structure of claim 58, wherein said at least one semiconductor device is formed at least partially in said second monocrystalline semiconductor material.

61. An electro-acoustic device, comprising

a monocrystalline semiconductor material substrate;

a piezoelectric material layer disposed in proximity to a top surface of said substrate;

a transducer disposed in proximity to a surface of said piezoelectric material layer, said transducer generating an acoustic wave in said piezoelectric material layer in response to a clock signal, said acoustic wave having associated electrical fields;

a gate electrode for applying a bias voltage to electrostatically displace said associated electric fields to form traveling potential wells in said substrate;

an input element for receiving an input signal, said input element injecting charge proportional to said input signal into said substrate, wherein said traveling potential wells periodically sample said injected charge and transport a sample charge packet away from said input element each time said injected charge is sampled; and

at least one output element that senses said amount of charge in said sample charge packet at a later time and generates an output signal proportional to amount of charge in said sample charge packet.

62. An electro-acoustic device defined in claim 61 wherein said monocrystalline semiconductor material substrate comprises a Group IV semiconductor material.

63. An electro-acoustic device defined in claim 61 wherein said piezoelectric material layer comprises a metallic oxide.

64. An electro-acoustic device defined in claim 63 wherein said metallic oxide comprises $Sr_zBa_{1-z}TiO_3$, where z has a value chosen between 0 and 1.

65. An electro-acoustic device defined in claim 61 wherein said piezoelectric material layer is lithium niobate.

66. An electro-acoustic device defined in claim 61 wherein said piezoelectric material layer is lithium tantalate.

67. The device defined in claim 61 wherein a substantial portion of charge transfer through said device is through a semiconductor substrate region proximate to said piezoelectric layer.

68. An electro-acoustic device defined in claim 61 wherein said input element comprises an input diode.

69. An electro-acoustic device defined in claim 61 wherein at least one of said output element comprises an output diode.

70. An electro-acoustic device defined in claim 61 further comprising an AC ground plane for promoting generation of Sezawa-mode acoustic waves.

71. The electro-acoustic device defined in claim 61 wherein said at least one semiconductor device is formed at least partially in said monocrystalline semiconductor material and wherein said at least one semiconductor device is electrically connected to at least one of said transducer, said gate electrode, said input element and said output element.

72. An electro-acoustic device, comprising

a monocrystalline semiconductor material substrate;

a piezoelectric material layer disposed in proximity to a top surface of said substrate;

a transducer disposed in proximity to a surface of said piezoelectric material layer, said transducer generating an acoustic wave in said piezoelectric material layer in response to a clock signal, said acoustic wave having associated electrical fields

a gate electrode for applying a bias voltage to electrostatically displace said associated electric fields to form traveling potential wells in said substrate;

an input element for receiving an input signal, said input element injecting charge proportional to said input signal into said substrate, wherein said traveling potential wells periodically sample said injected charge and transport a sample charge packet away from said input element each time said injected charge is sampled;

a plurality of laterally-spaced output elements that sense amounts of charge in said sample charge packets travelling across said output elements and generate sense signals proportional to said amounts of charge in said sample charge packets; and

signal processing circuitry fabricated in said monocrystalline semiconductor for receiving and

processing said sense signals to generate an output signal.

73. An electro-acoustic device defined in claim 72 wherein said input element comprises an input diode.

74. An electro-acoustic device defined in claim 72 wherein said signal processing circuitry comprises variable gain amplifiers that receive and process said sense signals.

75. An electro-acoustic device defined in claim 72 wherein said signal processing circuitry comprises variable gain amplifiers that receive and process said sense signals.

76. An electro-acoustic device defined in claim 75 wherein said signal processing circuitry further comprises high-impedance elements for coupling said output elements to said variable gain amplifiers.

77. An electro-acoustic device defined in claim 75 wherein said signal processing circuitry further comprises a summing circuit for adding said variable gain amplifiers outputs.

78. An electro-acoustic device defined in claim 75 wherein said signal processing circuitry further comprises a feedback circuit wherein said feedback circuit comprises second variable gain amplifiers that receive and process portions of said sense signals to generate feedback signals that are fed back to said input element.

79. An electro-acoustic device defined in claim 72 wherein said monocrystalline semiconductor material substrate comprises a Group IV semiconductor material.

80. An electro-acoustic device defined in claim 72 wherein said piezoelectric material layer comprises a metallic oxide.

81. An electro-acoustic device defined in claim 80 wherein said metallic oxide comprises $Sr_zBa_{1-z}TiO_3$, where z has a value chosen between 0 and 1.

82. An electro-acoustic device defined in claim 72 wherein said piezoelectric material layer is lithium niobate.

83. An electro-acoustic device defined in claim 72 wherein said piezoelectric material layer is lithium tantalate.

84. The device of claim 72 wherein said charge transport is by way of traveling potential wells, and wherein said potential wells are piezoelectrically coupled to an acoustic wave transduced in said piezoelectric layer.